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ABSTRACT

From the statewide assessment of mathematics performance conducted by the Minnesota Department of Education, specific study findings for 17-year-olds attending public and nonpublic schools included demographic data and information on student attitudes toward education programs and mathematics, and mathematics achievement. Data analyses suggested that students with no vocational education courses performed better in areas of higher mathematical concepts but that students with the most vocational education scored higher in practical applications of mathematical skills. The expectation that students in career and vocational education mathematics activities would acquire mathematical skills relevant to the world of work appeared confirmed. The major recommendation was that vocational educators should formulate mathematics objectives for their students so that a specific prediction of achievement differences might be tested. This project report includes 10 data tables including one that summarizes the findings. (MF)

FINAL REPORT

PROJECT NO. 7-D-75

STATEWIDE MATHEMATICS PERFORMANCE RELATED TO CAREER AND VOCATIONAL EDUCATION

Research and Development Project
in Career Education

Conducted Using Grant Awarded by
Division of Vocational-Technical Education
Minnesota Department of Education
Under Part C/D of Public Law 90-576

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August, 1976

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PREFACE

During the 1974-75 school year a statewide assessment of mathematics performance was conducted as part of the Minnesota Education Assessment Program. This effort was conducted by the office of Statewide Educational Assessment, Minnesota Department of Education.

Because of the implication for vocational education, the Division of Vocational-Technical Education provided support for that part of the study involving 17-year-old students. The report which follows describes the findings of that study as they pertain to the mathematics performance of students in vocational education.

SUMMARY OF THE REPORT

This report is derived from state-wide mathematics assessment results regarding mathematics performance of approximately 16,000 17-year-olds attending Minnesota public and nonpublic schools. In addition to student performance on mathematics items, data on students, school and district characteristics were collected to determine their relationship to mathematics performance. The present report is specifically concerned with the characteristics of vocational education students as derived from program, school and district data; and the relationship between these characteristics and mathematics achievement measured during the 1974-75 school year.

I. Deomographic Data

Approximately 62 percent of all 17-year-old students participating in the study had some vocational educatior courses, with slightly less than half of these participating in one year or less of courses. Participants were balanced in terms of gender at all levels of vocational education: 11 percent of males and 12 percent of females had participated in the maximal number of courses.

Students who participate in several vocational education courses (2½-3 years in grades ten through twelve) were

found to have career aspirations similar to those of students with no vocational education, i.e., showed in favor of the professions, but a higher percentage (38 versus 25) aspire to a skilled occupation. Interestingly, this increase appears to be due to fewer students with vocational education training wanting semi-skilled jobs as well as a slight decrease in the percentage aspiring to professional levels.

Vocational education students were distributed geographically in a somewhat different pattern than were students with no vocational education. The latter tend to be predominantly from suburban schools (42 percent), although there were also large numbers in small city and rural schools (37 percent), while the majority of the former were from small city and rural schools (57 percent). Large and medium city schools had approximately equal representation among nonvocational education and vocational education students. Students at all levels of vocational education were distributed by socioeconomic status in approximately the same form, although a lower percentage of students with one and one-half or more years of vocational education were from the highest SES level than were students with one year or less of vocational education.

II. Attitudes of 17-year-olds

Attitudes toward mathematics may be investigated in several ways. The most direct way, and the one used in this study, was to query students regarding their attitudes.

Approximately half of the students with no vocational education expressed a liking of mathematics. This percentage remains stable with increasing number of vocational education courses taken. Further, the proportion of students indicating they disliked mathematics was similar for those having no vocational education (14 percent) and those having taken the greatest amounts of vocational education (13 percent).

As attitudes toward mathematics appear to be highly related to the number of mathematics courses taken (without speculating as to the direction of causality), the number of mathematics courses may also be inspected. Again, the distributions for years in mathematics were nearly identical at different levels of vocational education. If there was any perceptible change, it was that fewer students with the largest amounts of vocational education had little or no (one year or less) high school mathematics (11 percent) versus 18 percent of students with no vocational education.

III Mathematics Achievement

The crucial questions asked here were:

1. how do students at varying levels of vocational education perfor ı;
2. were there differences in performance as a function of type of program, and
3. were there different patterns of achievement within the mathematics assessment for vocational education and nonvocational education students?

A. Overall performance: As indicated by the following information, the comparisons of total mathematics performance for vocational and nonvocational students was not conclusive.

Number of Years in Vocational-Technical Courses

	Mean Percent Correct
None	52.3%
½ to 1 year	53.3
1½ to 2 years	53.9
2½ to 3 years	53.6

B. Performance by Program Area: Mean performance by students in various vocational education programs does not appear to differ significantly from the state-wide mean of 53 percent, particularly with lower numbers of vocational education courses taken. Students in agribusiness and marketing/distribution programs scored slightly below the mean (49.6 percent) while students in business and office and technical programs scored slightly above the mean (54.5 percent and 55.6 percent, respectively). Some interaction between type of program and number of courses taken may, however, occur: the achievement of home economics students

with 3-4 courses declines to 46.2 percent, and to 43.4 percent with five or more courses. The effect of amount of vocational education is explored below.

C. Number of Vocational Education Courses: While there is some suggestion that performance may decline in some programs with increased numbers of courses, a more detailed analysis in terms of clusters of items and particular objectives suggests that with increasing numbers of vocational education courses, there may be a decline in some areas of mathematics achievement but an increase in others.

Generally, it appears that there are areas of mathematics in which students with no vocational education perform better (quadratics; graphing functions; finding equation of a graph) and related areas in which students with the most vocational education perform significantly below the state mean (knowledge of trigonometric terms, identifying a graph of a function, involving simultaneous equations, expanding binomials, and finding equation of a graph). However, on a set of objectives which can be characterized as practical applications of mathematical skills, students with the most vocational education courses scored significantly better than the group as a whole. Included in this set were knowledge

of basic operations, computational skills, interpolating and extrapolating from a table, solving verbal problems, applying formulas, and comparative buying. The analysis of objectives suggest that vocational education students, though they may be exposed to fewer higher level mathematical concepts, are proficient in making practical application of their mathematical skills.

BODY OF THE REPORT

A. Problem: One of the concerns of those involved in vocational education is the impact of career and vocational education courses on the basic skills of student participants. In particular, th present study was undertaken to assess the effects of vocati al education participation on the mathematics achievement of Minnesota 17-year-olds and to identify in-school variables related to mathematics achievement and attitudes of students who have not been enrolled in formal mathematics courses. Very little data relevant to this concern has been collected to date, despite the increasing demand for greater career relevancy in the secondary school cur iculum.

B. Goals and Objectives: The objectives of the present study parallel those developed for the Minnesota Education Assessment Program (MEAP), adapted to consider mathematics achievement and in-school variables related to vocational education:

1. To determine the level of performance of 17-year-old students in Minnestoa in various aspects of mathematics;
2. To delineate the attitudes toward educational programs and mathematics education of Minnesota 17-year-olds;

3. To identify the variables which account for the variation in student achievement and attitudes[1];

4. To report the results to educational decision-makers.

C. Description: Through mathematics related activities in career and vocational education there is an expectation that students will acquire competency and skills in mathematics which are relevant to the world of work. Therefore, this study sought to identify, through a survey of 16,000 in-school 17-year-olds randomly selected throughout Minnesota, the program characteristics associated with mathematics performance. The survey was conducted as part of a comprehensive MEAP which conducted a state-wide study of mathematics achievement of 17-year-olds in 1975.

Copies of the assessment instruments and survey materials used in this study may be found in Appendix 1. Where relevant, statistical tests of mean performance difference (t) were computed between distributional groups on each in-school variable.

[1] The primary variables explored in the current study are those directly related to vocational education participation or derived from it.

D. Results: With an increasing demand for career orientation in the secondary school curriculum, and with an increasing response to that demand in expanded vocational education curricula, some important questions may be raised regarding vocational education programs. The basic questions around which the data of this report may be organized are:

1. who are the students serviced by vocational education;
2. what relationship does vocational education have with students' attitudes toward schooling, and, as the particular emphasis of this report, toward mathematics; and
3. what are the mathematical abilities (achievement) of vocational education students so compared to state-wide norms.

Answers to these questions were sought by including inventory items in the student questionnaire of Minnesota State-Wide Educational Assessment of 17-year-old mathematics performance and examining relationships between questionnaire responses and mathematical performance.

1. Demographic Data

Table 1 displays percentages of 17-year-olds in nine cross-tabulated categories. Approximately 62 percent of all students have had some vocational education courses, with slightly less than half of these participating in one year or less of courses. Participants were balanced in terms of gender at all levels of vocational education: 11 percent of males and 12 percent of females have participated in the maximal number of courses.

Students who participate in several vocational education courses (2½ - 3 years) have career aspirations generally similar to students with no vocational education but a higher percentage (38 versus 25) aspire to a skilled occupation.

PERCENTAGE OF SEVENTEEN-YEAR-OLDS IN EACH CATEGORY
MATHEMATICS ASSESSMENT, 1975

		SEX		CAREER ASPIRATIONS			ATTITUDE TOWARD MATH			YEARS IN MATHEMATICS				
		Male	Female	Semi-skilled	Skilled	Professional	Dislike it	It's O.K.	Like it	None	½ - 1	1½ - 2	2½ - 3	3½ or more
SEX	Male			43	49	50	58	53	41	63	46	42	51	64
	Female			57	50	49	41	46	58	35	53	58	49	36
CAREER ASPIRATION	Semi-skilled, etc.,	7	9				15	10	4	14	16	10	4	2
	Skilled	30	29				29	35	25	24	37	36	24	16
	Professional, etc	53	50				39	43	63	38	32	43	63	74
ATTITUDE TOWARD MATHEMATICS	Dislike it	14	10	23	12	9				41	20	13	8	7
	It's O.K.	45	37	52	48	34				39	50	45	37	30
	Like it	40	53	25	40	57				18	30	41	55	63
YEARS IN MATHEMATICS	None	1	1	1	1	1	3	1	0					
	½ - 1	15	16	32	20	10	26	19	10					
	1½ - 2	32	42	45	44	31	41	41	33					
	2½ - 3	36	33	19	28	42	24	31	41					
	3½ or more	15	8	2	6	17	7	8	16					
YEARS IN VOCATIONAL/ TECHNICAL EDUCATION	None	38	38	42	32	39	43	37	37	63	42	37	37	36
	½ - 1	28	26	27	26	28	26	28	27	17	29	26	27	27
	1½ - 2	22	24	20	26	23	19	24	24	10	21	24	24	24
	2½ - 3	11	12	11	15	10	12	11	12	3	8	12	12	13
ADJUSTED MAINTENANCE COST/PUPIL	≤$ 725	14	13	18	15	12	14	15	12	6	17	15	12	11
	$726-890	42	41	44	44	40	43	43	40	42	45	44	39	37
	>$890	36	36	31	34	38	35	35	37	49	33	32	39	42
SIZE OF COMMUNITY	Large City	12	16	11	14	14	12	14	15	17	10	13	15	16
	Suburban	32	30	25	27	34	34	29	32	38	23	31	34	33
	Medium City	9	9	8	7	9	7	8	10	10	8	9	9	9
	Small City/Rural	47	46	56	51	42	46	49	43	35	59	47	42	41
PUPIL SOCIO-ECONOMIC STATUS	Low	19	21	37	25	14	24	23	17	15	29	23	16	13
	Middle	58	57	54	64	55	57	59	57	62	60	60	56	53
	High													
USE OF CALCULATOR OR COMPUTER	Neither													
	Calculator only													
	Computer only													
	Both													

TABLE 1 (Continued)

		PUPIL SOCIO-ECONOMIC STATUS			USE OF CALCULATOR OR COMPUTER			
		LOW	MIDDLE	HIGH	NEITHER	CALCULATOR ONLY	COMPUTER ONLY	BOTH
SEX	MALE	46	49	49	42	47	51	58
	FEMALE	54	51	50	56	52	49	41
CAREER ASPIRATION	SEMI-SKILLED, ETC.	15	7	3	10	8	6	5
	SKILLED	37	33	14	31	31	26	26
	PROFESSIONAL, ETC.	36	49	73	45	51	58	60
ATTITUDE TOWARD MATH	DISLIKE IT	14	12	10	14	11	12	11
	IT'S O.K.	47	42	33	43	40	42	37
	LIKE IT	39	46	56	42	49	46	53
YEARS IN MATHEMATICS	NONE	1	1	1	1	0	1	1
	½ - 1	22	16	8	23	14	11	7
	1½ - 2	42	38	29	40	36	39	30
	2½ - 3	27	34	45	28	37	37	43
	3½ - 4	7	11	18	6	12	12	19
YEARS IN VOCATIONAL/ TECHNICAL EDUCATION	NONE	36	36	45	37	37	40	37
	½ - 1	28	27	27	26	28	28	26
	1½ - 2	24	25	19	22	24	22	2,
	2½ - 3	12	12	8	11	12	11	11
ADJUSTED MAINTENANCE COST/PUPIL	≤$725	18	14	8	13	15	10	15
	$726 - 890	43	44	33	40	44	42	42
	>$890	32	33	46	36	33	39	39
SIZE OF COMMUNITY	LARGE CITY	15	13	15	15	9	20	13
	SUBURBAN	20	30	44	28	24	44	37
	MEDIUM CITY	7	8	11	10	10	5	7
	SMALL CITY/RURAL	58	48	30	47	56	32	42
PUPIL SOCIO-ECONOMIC STATUS	LOW				23	20	18	16
	MIDDLE				57	60	57	56
	HIGH				18	20	25	28
USE OF CALCULATOR OR COMPUTER	NEITHER	45	39	33				
	CALCULATOR ONLY	24	26	23				
	COMPUTER ONLY	12	13	15				
	BOTH	18	22	30				

		YEARS IN VOCATIONAL/ TECHNICAL EDUCATION				ADJUSTED MAINTENANCE COST/PUPIL			SIZE OF COMMUNITY			
		NONE	½ - 1	1½ - 2	2½ - 3	≤ $725	$726-890	> $890	LARGE CITY	SUBURBAN	MEDIUM CITY	SMALL CITY/ RURAL
SEX	MALE	49	50	47	46	49	49	49	42	50	48	49
	FEMALE	51	49	53	53	50	50	50	57	49	51	50
CAREER ASPIRATION	SEMI-SKILLED,ETC.	9	8	7	7	11	8	7	6	6	7	9
	SKILLED	25	29	33	38	33	31	28	31	25	25	32
	PROFESSIONAL,ETC.	53	53	51	46	46	49	54	52	56	55	47
ATTITUDE TOWARDS MATHEMATICS	DISLIKE IT	14	12	10	13	13	13	12	10	13	10	12
	IT'S O.K.	41	42	42	39	45	42	39	40	38	37	44
	LIKE IT	46	46	48	48	42	45	48	49	48	52	44
YEARS IN MATHEMATICS	NONE	1	1	0	0	0	1	1	1	1	1	1
	½ - 1	17	17	14	11	20	17	14	11	11	14	20
	1½ - 2	36	36	39	39	40	38	33	35	36	37	37
	2½ - 3	35	35	35	36	30	33	38	38	38	35	31
	3½ or more	11	11	12	14	9	10	13	14	12	12	10
YEARS IN VOCATIONAL/ TECHNICAL EDUCATION	NONE					30	35	43	35	51	32	30
	½ - 1					30	27	25	29	22	29	29
	1½ - 2					25	24	21	26	18	23	26
	2½ - 3					14	12	9	9	7	15	14
ADJUSTED MAINTENANCE COST/PUPIL	≤ $725	11	15	15	17				0	0	0	29
	$726-890	39	41	44	45				0	45	24	56
	> $890	41	34	33	30				75	49	58	12
SIZE OF COMMUNITY	LARGE CITY	13	15	16	11	0	0	29				
	SUBURBAN	42	26	24	20	0	33	42				
	MEDIUM CITY	7	9	9	11	0	5	14				
	SMALL CITY/RURAL	37	49	51	57	99	62	15				
PUPIL SOCIO-ECONOMIC STATUS	LOW	19	20	20	21	27	21	18	21	13	17	25
	MIDDLE	54	57	61	64	60	61	53	54	55	55	60
	HIGH	26	22	18	16	13	17	28	24	31	27	14
USE OF CALCULATOR OR COMPUTER	NEITHER	39	39	38	39	38	38	39	44	35	44	40
	CALCULATOR ONLY	24	25	25	26	27	26	22	16	19	30	30
	COMPUTER ONLY	14	14	12	13	10	13	14	19	18	7	9
	BOTH	23	23	25	23	25	23	25	22	28	19	21

Vocational education students are distributed geographically in a somewhat different pattern than are students with no vocational education; the latter tend to be predominantly from suburban schools (42 percent), although there are also large numbers in small city and rural schools (37 percent). The majority of the former are from small city and rural schools (57 percent). Large and medium city schools have approximately equal representation among non-vocational education and vocational education students. Students at all levels of vocational education are distributed by socioeconomic status in approximately the same form, although a lower percentage of students with one and one-half or more years of vocational education are from the highest SES level than students with one year or less of vocational education.

From an administrative standpoint, it should also be noted that students with higher numbers of vocational education courses are related to slightly lower adjusted maintenance costs per pupil; where as 41 percent of students with no vocational education fall in the highest cost category ($890), the percentage declines with number of vocational education courses, to 30 percent for those with 2½-3 years of vocational education.

Lastly, the distribution of vocational education students by program is shown in Tables 2 and 3. A qualification

should be placed on the interpretation of the large number indicating participation in vocational health programs; the questionnaire item was apparently construed as "health and physical education," a required part of the curriculum for many. With this exception, the largest participation appears to be in

1. business and office,
2. home economics and
3. trade and industrial programs.

For all programs, the numbers of students taking one or two courses is several times that of students taking more courses.

2. Attitudes

Attitudes toward mathematics may be investigated in several ways; most directly, students were queried regarding their attitudes. Approximately half of the students with no vocational education express liking of mathematics, and this percentage remains stable with increasing number of vocational education courses. Further, the proportion of students indicating they disliked mathematics was similar for no vocational education (14 percent) and the highest amounts of vocational education (13 percent).

As attitudes toward mathematics appear to be highly related to the number of mathematics courses taken (without speculating as to the direction of causality), number of mathematics courses taken may also be inspected. Again, the distributions for years in mathematics are nearly identical at different levels of vocational education. If there is any perceptible change, it is that fewer students with the largest amounts of vocational education have had little or no (one year or less) high school mathematics (11 percent of these students) versus 18 percent of students with no vocational education.

Finally, we may inquire as to whether some aspects of the mathematical education of vocational education students differ from that of nonvocational education students; a question reflecting one possible difference is experience with computers or calculators. There are no differences among students at different levels of vocational education in such experiences. The critical variable for calculator/computer use appears to be community size.

TABLE 2

AVERAGE (MEAN) PERCENT CORRECT FOR VOCATIONAL/TECHNICAL STUDENTS

1975

Program Area	Number of Vocational/Technical Courses in Area (Grades 10-12)					
	One or Two		Three or Four		Five or More	
	Performance	N	Performance	N	Performance	N
Agri-Business	49.6%	1485 (.10)	50.6%	406 (.03)	48.4%	159 (.01)
Marketing and Distribution	49.6%	1407 (.09)	44.5%	133 (.01)	—	16 **
Health	53.9%	7639 (.49)	47.4%	515 (.03)	—	77 **
Home Economics	51.5%	4306 (.28)	46.2%	1440 (.09)	43.4%	362 (.02)
Business and Office	54.5%	5408 (.35)	51.1%	1320 (.09)	49.3%	481 (.03)
Technical	55.6%	1610 (.10)	55.8%	333 (.02)	—	90 **
Trade and Industrial	52.2%	2625 (.11)	52.6%	924 (.06)	48.8%	480 (.03)

This based on a sample of approximately 16,000 17-year-old students across the state.

STATEWIDE PERFORMANCE OF ALL 17-YEAR-OLDS WAS 53.0%.

** Number of students in this category is less than 1% of sample.

NUMBER OF STUDENTS IN VOCATIONAL/TECHNICAL CLASSES
1975

RAM AREA		NUMBER OF COURSES								
		NONE		1 OR 2		3 OR 4		5 OR MORE		NO RESPONSE
		NUMBER	PERCENT*	NUMBER	PERCENT*	NUMBER	PERCENT*	NUMBER	PERCENT*	NUMBER
	MALE	5861	45%	964	65%	343	85%	131	83%	196
	FEMALE	7138	55	506	34	56	14	28	18	
ISTRIBUTION	MALE	6576	48	642	46	65	49	9	56	218
	FEMALE	6886	51	753	54	68	51	7	44	
	MALE	3830	56	3204	42	218	42	43	57	221
	FEMALE	3002	44	4377	57	294	57	33	43	
S	MALE	4897	60	1452	20	125	9	16	6	217
	FEMALE	3262	40	5622	79	1299	90	246	94	
FICE	MALE	5083	65	1903	35	257	19	42	9	244
	FEMALE	2741	35	3492	64	1046	79	440	91	
	MALE	5703	44	1222	76	280	84	84	93	219
	FEMALE	7282	56	375	23	50	15	6	7	
TRIAL	MALE	4030	36	1953	74	850	92	455	94	222
	FEMALE	6977	63	652	25	64	7	20	4	

centages do not always total 100 due to non responses.

3. Mathematics Achievement

The crucial questions to be asked here were:

1. how do students at varying levels of vocational education perform;
2. were there differences in performance as a function of type of program and
3. were there different patterns of achievement within the mathematics assessment for vocational education and nonvocational education students.

(a) Overall performance: As indicated by the following display, the comparisons of total mathematics performance for vocational and nonvocational students was not conclusive.

Number of Years in Vocational-Technical Courses

	Mean Percent Correct
None	52.3%
½ to 1 year	53.3
1½ to 2 years	53.9
2½ to 3 years	53.6

(b) Performance by Program Area: Mean performance by students in various vocational education programs does not appear to differ significantly from the state-wide mean of 53.0 percent, particularly with lower numbers of vocational

education courses taken. Students in agribusiness and marketing/distribution programs scored slightly below the mean (49.6 percent) while students in business and office and technical programs scored slightly above the mean (54.5 percent and 55.6 percent, respectively). Some interaction between type of program and number of courses taken may, however, occur. The achievement of home economics students with 3-4 courses declines to 46.2 percent, and to 43.4 percent with five or more courses. The effect of amount of vocational education is explored below.

(c) Number of Vocational Education Courses: While there is some suggestions that performance may decline in some vocational programs with increased numbers of courses, a more detailed analysis in terms of clusters of items and particular objectives suggests that with increasing numbers of vocational education courses, there may be a decline in certain areas of mathematics achievement but an increase in others. Tables 4 and 5 indicate achievement on each cluster at various levels of vocational education (see Appendix 2 for description of clusters) and Table 6 provides the same type of analysis at the level of specific objectives. The objectives are described in Appendix 3.

Summarizing these analysis, it appears that there are areas of mathematics in which students with no vocational education perform better (quadratics; graphing functions; finding the equation of a graph) and related areas in which students with

the most vocational education perform significantly below the state mean (knowledge of trigonometric terms, identifying a graph of a function, solving simultaneous equations, expanding binomials, and finding equation of a graph). However, on a set of objectives which can be characterized as practical applications of mathematical skills, students with the most vocational education courses scored significantly better than the group as a whole. Included in this set were knowledge of basic operations, computational skills, interpolating and extrapolating from a table, solving verbal problems, applying formulas, and comparative buying. The objectives are summarized in Table 7 and suggest that vocational education students, though they may be exposed to fewer higher level mathematical concepts, are proficient in making proctical application of their mathematical skills.

TABLE 4

SEVENTEEN-YEAR-OLD MATHEMATICS PERFORMANCE ON CLUSTERS
GROUPED BY
TYPE OF VOCATIONAL-TECHNICAL CLASSES

Math Cluster[1]	Statewide Performance*	Agri.-Business		Mkt.-Dist.		Health		Home Ec.		Bus. & Off.		Technical		Trade & Ind.	
		1-2	3+	1-2	3+	1-2	3+	1-2	3+	1-2	3+	1-2	3+	1-2	3+
C1	91.8	91.5	90.0	91.1	91.4	92.2	90.8	92.3	90.5	93.1	93.6	91.2	89.8	91.0	89.7
C2	61.3	57.9	60.4	55.3	48.3	61.8	55.1	58.5	50.9	62.2	58.4	66.4	63.3	61.0	62.9
C3	51.8	48.8	49.9	48.3	44.4	52.3	44.2	49.7	43.2	54.5	55.4	55.2	51.1	51.3	47.3
P1	61.5	55.8	55.2	56.6	48.7	62.9	55.1	59.5	52.6	62.7	59.0	62.5	65.1	59.8	58.3
B1	61.6	57.1	56.9	57.5	52.6	62.5	55.6	59.5	53.9	63.0	57.4	64.3	65.3	60.7	61.2
G2	52.5	48.4	51.6	47.8	41.9	53.0	47.6	49.9	41.7	52.7	47.7	56.7	57.5	52.8	55.2
A1	49.4	46.1	45.2	46.0	36.8	52.6	45.0	49.9	42.0	53.8	47.6	53.5	54.3	48.9	46.9
A2	35.2	31.2	30.4	31.9	24.7	35.9	30.7	33.2	28.1	36.5	31.4	37.6	36.9	33.4	32.3
I1	51.4	48.8	49.4	48.9	41.0	52.0	45.8	49.4	42.9	52.2	48.5	54.0	55.3	50.9	51.4
PS1	63.4	62.4	62.6	60.5	56.0	63.8	56.0	61.1	54.8	64.9	62.8	67.4	64.9	64.0	64.3
PS2	44.8	40.0	40.9	40.0	36.1	44.5	38.2	42.5	37.8	45.2	41.6	45.1	46.1	42.7	40.0
M1	58.4	73.4	73.5	69.0	60.9	74.7	69.6	72.5	63.1	74.6	68.6	82.3	78.7	76.8	77.3
SP	25.1	23.2	24.3	24.4	19.4	25.8	16.7	23.6	21.3	25.7	23.0	26.8	24.8	24.4	22.3
S1	70.9	64.9	65.1	66.4	66.7	72.3	60.9	69.4	66.5	74.2	71.2	71.9	70.6	70.1	65.4
T1	17.1	18.3	16.9	14.4	15.1	19.9	17.2	17.9	16.4	19.9	14.9	22.6	20.8	19.0	17.4

*Indicates the average percent of items correct for Minnesota 17-year-olds.

[1] See appendix for description of clusters.

TABLE 5
NUMBER OF YEARS IN VOCATIONAL/TECHNICAL COURSES (10-12)

Cluster (Number of Items)	Description	PERCENT CORRECT Number of Years in Vocational/Technical (10-12)				Comment
		None	½ - 1	1½ - 2	2½ - 3	
C1 (12)	Computation with whole numbers	91.4	91.9	92.6*	92.8*	More voc/tech significantly above state mean
C2 (10)	Concepts and computation with common fractions	60.0*	61.0	63.1*	64.4*	Less voc/tech < more voc/tech
C3 (9)	Concepts and computations with decimal numbers	50.3*	51.2	54.2	55.5*	Less voc/tech < more voc/tech
P1 (12)	Properties of numbers	61.1	60.9	62.8*	62.3	
G1 (21)	Recognition of geometric properties	61.1	62.7*	62.3	61.4	
G2 (18)	Applications of geometric properties	51.9	52.0	53.6	54.8*	Most voc/tech significantly above state mean
A1 (25)	Algebraic expressions	49.0	50.0	50.6*	48.5	
A2 (27)	Algebraic applications	34.8	36.3*	35.2	34.5	
I1 (14)	Interpret graphs, tables and maps	50.9	51.8	51.7	52.7	
PS1 (16)	Basic problem solving	62.1*	62.9	65.3*	66.6*	Less voc/tech < more voc/tech
PS2 (40)	Advanced problem solving	44.1*	45.4	45.4	45.4	No voc/tech significantly below state mean
M1 (9)	Measurement systems	58.1	59.3	58.0	58.5	
SP (6)	Statistics and probability	25.1	25.7	24.5	25.3	
S1 (3)	Sets	69.7	70.8	73.2*	72.1	
(5)	Trigonometry	19.7	21.0	19.9	16.8*	Most voc/tech significantly below state mean

TABLE 6

OBJECTIVE ANALYSIS 17-YEAR-OLD MATHEMATICS ASSESSMENT

Objective (number of items)		Description	Number of Years in Vocational/Technical (10-12) (Percent Correct) None (N=3533)	½ - 1 (N=2852)	1½ - 2 (N=2466)	2½ - 3 (N=1303)	Comment
IA1	(3)	Knowledge of basic add.,sub., mult. and div.	95.8%*	97.1%	97.2%	97.4%	Less voc/tech<more voc/ tech
IA2	(5)	Knowledge of percent and ratio	40.8	40.1	43.2	44.7*	
IC3	(4)	Knowledge of f(x), log x, exp x, exponential notation, cartesian pairs	46.8	47.5	46.9	45.8	
IE1	(7)	Knowledge of terms: variable, coordinate, etc.	61.7	63.6	63.4	62.1	
IE2	(2)	Knowledge of terms: functions, inverse	38.0	39.8	40.9	39.1	
IF1	(7)	Knowledge of terms: parallel, similar, ray, etc.	75.9*	78.3*	78.2	77.0	
IF2	(4)	Knowledge of figures: circles, polygons, etc.	88.3	89.2	91.3*	90.2	
IG1	(1)	Knowledge of terms: elem. analytic geometry, slope, etc.	57.1	55.5	57.0	53.6	
IG2	(3)	Knowledge of terms: trig. - sine, cosine, rt. triangle, etc.	21.4	22.4	21.4	16.5*	Most voc/tech significantly below state mean
I I	(3)	Knowledge of trig. functions: 30-60-90 tri., 45-45-90 tri.	22.8	25.4*	23.5	24.3	
I J	(3)	Knowledge of geometric facts	37.9	38.4	35.5	36.5	
I K	(3)	Laws for exponents and logs	40.9	40.9	43.0*	38.7	
I L2	(3)	Identify graphs: parabola, hyperbola, ellipse	38.1	38.8	35.0	32.2*	Most voc/tech significantly below state mean
I Q	(1)	Scientific notation	71.1	67.6*	74.4*	73.6	
I R	(6)	Metric System	71.1	72.2	71.3	71.6	
I S	(1)	Nec. and suff. conditions, inverse, etc.	48.4*	52.4	51.9	57.4*	Less voc/tech<more voc/ tech
IIA	(15)	Computation with approximate data	78.4*	79.5	81.8*	82.1*	Less voc/tech<more voc/ tech
IIB	(8)	Manipulation of algebraic expressions (1st degree polynominals)	45.3	45.8	46.2	45.2	
II G	(2)	Conversion relations in measurement	30.1	30.7	29.3	29.7	
IIJ1	(2)	Solving simultaneous (linear) equations	13.6	13.5	12.0	9.2*	Most voc/tech significantly below state mean
IIJ2	(1)	Solving simultaneous (linear and quad) equations	11.3*	15.9	16.9*	12.3	Less voc/tech<more voc/ tech
II N	(3)	Interpolation and extrapolation with table	55.2	54.5	54.9	58.2*	Most voc/tech significantly above state mean
IIP	(1)	Synthetic division	5.1	3.1*	5.6	3.1	
IIQ	(2)	Expanding a binomial	29.9	30.2	30.3	26.1*	Most voc/tech significantly below state mean.
IIR	(1)	Reading graphs	91.8	93.2	94.3	93.8	
IIS	(3)	Using formulas	74.6*	75.5	78.2*	79.2*	Less voc/tech<more voc/ tech

* Indicates significant difference ($p \leq .05$) from state percentage correct for objective.

Objective (Number of Items)		Description	Number of Years in Vocational/Technical (10-12) (Percent Correct) None	½ - 1	1½ - 2	2½ - 3	Comment
IIT1	(8)	Solve equations and inequalities in one variable	47.0*	48.8	48.8	47.6	Less voc/tech significa below state mean
IIT2	(5)	Solve equations and inequalities (quad)	23.4	26.3*	23.2	21.4*	Less voc/tech > more vo tech
IIIA1	(2)	Make a graph of a function (linear)	42.8	43.8	42.8	46.0	
IIIA2	(4)	Make a graph of a function (quad and higher)	23.0	25.0*	23.3	19.7*	Less voc/tech>more voc, tech
IIIB1	(2)	Finding equation of graph (linear)	19.6	19.5	17.7	15.4*	Most voc/tech significa below state mean
IIIB2	(1)	Finding euqation of graph (quad and higher)	6.6	8.2*	4.6*	2.3*	Less voc/tech>more voc, tech
IIIJ	(4)	Interp. stat. data: mean, mode, mdn. etc.	19.5	20.8	19.8	20.1	
IIIK	(5)	Translating verbal to math sentence	56.9	57.5	58.7	60.8*	Most voc/tech significa above state mean
IIIL	(1)	Illustrating geom. theorem by making sketch	57.0	54.1	55.9	55.0	
IVA	(1)	Solution of triangles using trig. ratios	11.3	13.3	12.2	10.5	
IVC1	(3)	Solving verbal probs. (simple linear, one variable)	42.9	44.9	44.9	47.7*	Most voc/tech significa above state mean
IVC3	(3)	Solving verbal probs. (2 or more var., 2nd degree equation)	24.0	23.8	23.9	23.0	
IVE	(2)	Interp. tables & graphs	69.8	71.7	70.2	74.2*	Most voc/tech significa above state mean
IVF	(6)	Applying formulas	55.7*	56.1	59.8*	59.8*	Less voc/tech<more voc/ tech
IVH	(3)	Computing with complex numbers	33.2	34.3	34.5	30.7	
IVL	(1)	Locating a flaw in geom. proof	22.9	22.4	20.9	20.8	
IVM	(1)	Locating a flaw in algebraic proof	12.9	10.9	10.6	11.7	
IVR	(1)	Solving shop problems	18.4	17.0	20.5	19.6	
IVU	(2)	Estimation	56.3*	59.3	58.8	60.0	No voc/tech significant below state mean
IVV	(1)	Translation of problem into flow chart	41.8*	48.0	45.1	46.5	
IVW	(4)	Solve consumer problems: tax, ins., etc.	61.3*	62.0	64.8*	66.5*	Less voc/tech<more voc/ tech
VA	(2)	Geometric experiments	49.3	51.0	51.5	52.7	
VB	(3)	Patterns & generalizations about configurations	60.4	60.8	62.3	62.6	
VC	(6)	Solving novel probs., puzzles	38.8*	41.0	41.3	41.4	No voc/tech significant below state mean
VD	(2)	Comparative buying	49.9*	52.3	53.1	55.6*	Less voc/tech<more voc/ tech
VF	(1)	Budgeting	29.5	30.5	30.9	33.4	
VH	(1)	Discover fallacies in consumer ad	53.7	53.5	55.5	52.4	
VP1	(2)	Prob. solv.: counter examples	49.0*	51.5	51.5	52.8	No voc/tech significant below state mean
VP2	(2)	Problem solving: use of similar case	35.7	33.7	35.8	36.9	
VP3	(2)	Prob. Solv.: Looking at extremes	51.1	51.7	53.7	50.6	
VP4	(2)	Prob. Solv.: Assume answer known	51.8	52.7	52.7	51.9	
	(5)	Prob. solv.: Analysis of problems	67.4	68.2	68.1	68.2	

TABLE 7

SUMMARY OF FINDINGS

Objectives on which students with NO voc/tech, or the least voc/tech performed significantly better than the group as a whole	Objectives on which students with more or the most voc/tech performed significantly better than group as whole
IIT2 - Solving equations and inequalities of quadratics IIIA2 - Make a graph of a function (quadratic and higher) IIIB2 - Finding equation of graph (quadratic and higher)	IA1 - Knowledge of basic add., sub., mult., and div. IS - Necessary and sufficient conditions, inverse, etc. IIA - Computation with approximate data IIJ2 - Solving simultaneous (linear and quad.) equations IIN - Interpolating and extrapoling with table IIS - Using formulas
Objectives on which students with the most voc/tech were significantly below the group mean	IIIK - Translating verbal to mathematical statement IVC1 - Solving verbal problems; simple linear with one variable
IG2 - Knowledge of trig terms IL2 - Identify graph of functions IIJ1 - Solving simultaneous linear equations IIQ - Expanding a binomial IIIB1 - Finding equation of a graph (linear)	IVE - Interpreting tables and graphs IVF - Applying formulas IVW - Solving consumer problems VD - Comparative buying

E. Evaluation: The present study has attempted to determine the characteristics of students served by vocational education programs, their attitudes toward mathematics, and their mathematical achievement. In terms of the information provided by the MEAP instruments and survey data, it has been possible to determine that vocational education students

1. excel in some practical applications of mathematical knowledge,
2. show slightly lower performance in advanced theoretical areas, and
3. their attitudes toward mathematics are not substantially different from those of students who have not participated or participated less in vocational education courses.

Suggestion of limitations and further design refinements are made below.

F. Conclusions, implications and recommendations: The major conclusions of this study may be summarized as follows:

1. Vocational education students are similar in many demographic characteristics to nonvocational education students; the major differences are that vocational education represent small city and rural schools to a greater extent, underrepresent the highest SES level, and tend to be related to slightly lower adjusted maintenance costs per pupil.

2. Vocational educational students show the same distribution of attitudes towards mathematics as nonvocational education students, and have taken equivalent numbers of mathematics courses as the general high school population.

3. Vocational education students do not significantly differ from nonvocational education students in overall mathematics achievement; they may, however, perform better in terms of practical applications of mathematical skills and slightly below the overall mean in more advanced and/or theoretical mathematical concepts.

The implications of these findings seem similarly straightforward:

1. Vocational education is not significantly related to attitudes toward, participation in, or benefit from mathematics courses in terms of either boosting or depressing performance on the measures used here. On general measures, the distribution of vocational education and nonvocational education students do not differ significantly.

2. If there are differences in mathematics achievement, they appear at the level of particular objectives and indicate the relative success of vocational education programs: the vocational

education students performed significantly better in terms of practical applications of mathematics and "real-world" skills.

The major recommendation to be made following this study is that the ad hoc nature of the objectives analysis should be corrected: vocational educators should be encouraged to formulate mathematics objectives in which their students are trained, such that a specific prediction of achievement differences might be tested.